DRAFT

Grade 6–8

Physical Science

Item Specifications

Updated February 2020

Missouri
DEPARTMENT OF ELEMENTARY & SECONDARY
EDUCATION

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Introduction

In 2014 Missouri legislators passed House Bill 1490, mandating the development of the Missouri Learning Expectations. In April of 2016, these Missouri Learning Expectations were adopted by the State Board of Education. Groups of Missouri educators from across the state collaborated to create the documents necessary to support the implementation of these expectations.

One of the documents developed is the item specification document, which includes all Missouri grade level/course expectations arranged by domains/strands. It defines what could be measured on a variety of assessments. The document serves as the foundation of the assessment development process.

Although teachers may use this document to provide clarity to the expectations, these specifications are intended for summative, benchmark, and large-scale assessment purposes.

Components of the item specifications include:

Expectation Unwrapped breaks down a list of clearly delineated content and skills the students are expected to know and be able to do upon mastery of the Expectation.

Depth of Knowledge (DOK) Ceiling indicates the highest level of cognitive complexity that would typically be assessed on a large scale assessment. The DOK ceiling is not intended to limit the complexity one might reach in classroom instruction.

Item Format indicates the types of test questions used in large scale assessment. For each expectation, the item format specifies the type best suited for that particular expectation.

Content Limits/Assessment Boundaries are parameters that item writers should consider when developing a large scale assessment. For example, some expectations should not be assessed on a large scale assessment but are better suited for local assessment.

Sample stems are examples that address the specific elements of each expectation and address varying DOK levels. The sample stems provided in this document are in no way intended to limit the depth and breadth of possible item stems. The expectation should be assessed in a variety of ways.

Possible Evidence indicates observable methods in which a student can show understanding of the expectations.

Stimulus Materials defines types of stimulus materials that can be used in the item stems.

Physical Sciences		6-8.PS1.A.1
Core Idea	**Matter and Its Interactions**	
Component	**Structure and Properties of Matter**	
MLS	Develop models to describe the atomic composition of simple molecules and extended structures.	

Expectation Unwrapped	**DOK Ceiling**
	3
[Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball-and-stick structures, or computer representations showing different molecules with different types of atoms.] **SCIENCE AND ENGINEERING PRACTICES** **Developing and Using Models** ● Develop a model to predict and/or describe phenomena. **DISCIPLINARY CORE IDEAS** **Structure and Properties of Matter** ● Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. ● Solids, liquids and gases may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). **CROSSCUTTING CONCEPTS** **Scale, Proportion, and Quantity** ● Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.	**Item Format** Selected Response Constructed Response Technology Enhanced
Content Limits/Assessment Boundaries	**Sample Stems**
● Tasks should avoid valence electrons, bonding energies, and the charge and structure of subatomic particles. ● Tasks should avoid complete depictions of all individual atoms in a complex molecule or extended structures.	John's teacher challenged his classmates and himself to draw three models: 1) a single atom; 2)a molecule made of two or more of the same atom; and 3)a molecule made of two or more different atoms. John and his

Possible Evidence	classmates were not sure where to start since they had not ever seen atoms or molecules before.
- Students build or identify a simple model of a molecule given basic elements, for example carbon, hydrogen, nitrogen, oxygen. - Students describe how the periodic table is organized (e.g., metals, nonmetals, atomic mass). - Students evaluate whether a given model is a simple molecule or extended structure. - Students develop atomic composition models of simple molecules and extended structures that vary in complexity. In the models, students identify the relevant components, including - individual atoms. - molecules. - extended structures with repeating subunits. - substances (e.g., solids, liquids, and gases at the macro level). - Students use models to describe that pure substances are made up of a bulk quantity of individual atoms or molecules. Each pure substance is made up of one of the following: - Individual atoms of the same type that are connected to form extended structures - Individual atoms of different types that repeat to form extended structures (e.g., sodium chloride) - Individual atoms that are not attracted to each other (e.g., helium) - Molecules of different types of atoms that are not attracted to each other (e.g., carbon dioxide). - Molecules of different types of atoms that are attracted to each other to form extended structures (e.g., sugar, nylon). - Molecules of the same type of atom that are not attracted to each other (e.g., oxygen)	1. Develop a model for each of the three cases described above. 2. Assume a student used hydrogen gas and water as two of their models. How could you compare how much of the properties of hydrogen gas compares to the properties of a molecule of water? Monomers are molecules that can be large or small (only one or two atoms). Polymers are the products of polymerization (monomers joining together). Polymers can be long chains or they could be bigger web-like structures. Polymers are always made from smaller pieces called monomers. 1. Based on the information above, develop a model to show the following: A. a monomer B. polymerization C. a polymer
Stimulus Materials Graphic organizers, diagrams, graphs, data tables, drawings	

Physical Sciences		6-8.PS1.A.2
Core Idea	**Matter and Its Interactions**	
Component	**Structure and Properties of Matter**	
MLS	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.	

Expectation Unwrapped	**DOK Ceiling**
	3
[Clarification Statement: Examples of reactions could include but are not limited to burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] **SCIENCE AND ENGINEERING PRACTICES** **Analyzing and Interpreting Data** ● Analyze and interpret data to determine similarities and differences in findings. **DISCIPLINARY CORE IDEAS** **Chemical Reactions** ● Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. **Structure and Properties of Matter** ● Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **CROSSCUTTING CONCEPTS** **Patterns** ● Macroscopic patterns are related to the nature of atomic level structure.	**Item Format** Selected Response Constructed Response Technology Enhanced

Content Limits/Assessment Boundaries	Sample Stems
• Tasks should be limited to an analysis of the following properties: density, melting point, boiling point, solubility, flammability, and color. **Possible Evidence** • Students explain the difference between a physical change and a chemical change. • Students explain the difference between a physical property and a chemical property. • Students organize given data about the characteristic physical and chemical properties (e.g., density, melting point, boiling point, solubility, flammability, odor) of pure substances before and after they interact. • Students organize the given data in a way that facilitates analysis and interpretation. • Students analyze the data to identify patterns (i.e., similarities and differences), including the changes in physical and chemical properties of each substance before and after the interaction (e.g., before the interaction, a substance burns, while after the interaction, the resulting substance does not burn). • Students use the analyzed data to determine whether a chemical reaction has occurred. • Students support the interpretation of data by describing that the change in the properties of substances is related to the rearrangement of atoms in the reactants and products in a chemical reaction (e.g., when a reaction has occurred, atoms from the substances present before the interaction must have been rearranged into new configurations, resulting in the properties of new substances). **Stimulus Materials** Graphic organizers, diagrams, graphs, data tables, drawings	1. Classify the following situation as either a physical or chemical change. a. Baking soda and vinegar are mixed together causing bubbles to form. b. Water turns from liquid to gas at 100 degrees C c. Paper becomes ash after being lit on fire d. An iron nail rusts when its been exposed to rain over time e. A plastic pipe cracks when water freezes inside 2. What rule did you use to determine whether the change is physical or chemical A group of students conducted an investigation to determine how temperature affects the phase of a substance. To do so, they placed a solid form of the substance in a glass beaker. The glass beaker was then placed on a hot plate and the temperature was recorded every two minutes. The data is found in the table below.

Time (min)	Temp (Celsius)	State of Substance
0	-5	solid
2	-1	solid
4	0	solid and liquid
6	0	solid and liquid
8	0	solid and liquid
10	3.5	liquid
12	19.5	liquid
14	58	liquid
16	80	liquid
18	93	liquid
20	98	liquid and gas
22	100	gas liquid and gas
24	100	gas

1. Develop a graph to display the data provided in the data table.
2. What does the pattern of data you see allow you to conclude from the experiment?

Physical Sciences		6-8.PS1.A.3
Core Idea	**Matter and Its Interactions**	
Component	**Structure and Properties of Matter**	
MLS	Gather, analyze, and present information to describe that synthetic materials come from natural resources and how they impact society.	

Expectation Unwrapped

[Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicines, foods, and alternative fuels.]

SCIENCE AND ENGINEERING PRACTICES

Obtaining, Evaluating, and Communicating Information

- Gather, read, and synthesize information from multiple appropriate sources, assess the credibility, accuracy, and possible bias of each publication and method used, and describe how they are supported or not supported by evidence.

DISCIPLINARY CORE IDEAS

Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

Structure and Properties of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

CROSSCUTTING CONCEPTS

Structure and Function

- Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.

DOK Ceiling

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Item Format

Selected Response
Constructed Response
Technology Enhanced

Content Limits/Assessment Boundaries

- Tasks should be limited to qualitative information.
- Tasks should avoid the exact processes and chemical reactions involved in the creation of synthetic materials.

Possible Evidence

- Students obtain information or are given information from published, grade-level appropriate material from at least two sources (e.g., text, media, visual displays, data) about
  - synthetic materials and the natural resources from which they are derived.
  - chemical processes used to create synthetic materials from natural resources (e.g., burning of limestone for the production of concrete).
  - the societal need for the synthetic material (e.g., the need for concrete as a building material).
- Students determine and describe whether the gathered information is relevant for determining
  - that synthetic materials, via chemical reactions, come from natural resources.
  - the effects of the production and use of synthetic resources on society.
- Students determine the credibility, accuracy, and possible bias of each source of information, including the ideas included and methods described.
- Students synthesize information that is presented in various modes (e.g., graphs, diagrams, photographs, text, mathematical, verbal) to describe
  - how synthetic materials are formed, including the natural resources and chemical processes used.
  - the properties of the synthetic material(s) that make it different from the natural resource(s) from which it was derived.
  - how those physical and chemical properties contribute to the function of the synthetic material.
  - how the synthetic material satisfies a societal need or desire through the properties of its structure and function.
  - the effects of making and using synthetic materials on natural resources and society.

Stimulus Materials

Graphic organizers, text, diagrams, graphs, data tables, drawings

Sample Stems

A baby wipe is used to clean the baby after it has used the restroom. Look at the claim presented by the company in the picture. zs

1. a. Identify if the claim scientifically correct or incorrect.
   b. Support your response to Part A.

2. a. Identify the three materials that make up the Water Wipes system.
   b. Describe the function of each material identified in Part A.

3. Identify whether each material in Water Wipes could be classified as a chemical.

4. Identify whether each material in Water Wipes is natural or synthetic.

<table>
<tr><th colspan="2">Physical Sciences</th><th>6-8.PS1.A.4</th></tr>
<tr><td>Core Idea</td><td colspan="2">Matter and Its Interactions</td></tr>
<tr><td>Component</td><td colspan="2">Structure and Properties of Matter</td></tr>
<tr><td>MLS</td><td colspan="2">Develop a model that describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.</td></tr>
<tr><td colspan="2" rowspan="2"><u>Expectation Unwrapped</u>

[Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

<u>SCIENCE AND ENGINEERING PRACTICES</u>
Developing and Using Models
● Develop a model to predict and/or describe phenomena.

<u>DISCIPLINARY CORE IDEAS</u>
Structure and Properties of Matter
● Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
● In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
● The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

Definitions of Energy
● The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.
● Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.</td><td><u>DOK Ceiling</u>
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<tr><td><u>Item Format</u>
Selected Response
Constructed Response
Technology Enhanced</td></tr>
</table>

<u>CROSSCUTTING CONCEPTS</u>

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

<u>Content Limits/Assessment Boundaries</u>

- Tasks should be limited to qualitative models.
- Tasks should not require student to label diagrams.

<u>Possible Evidence</u>

- Students develop/identify a model that accurately displays the arrangement of particles of solids, liquids, and gases.
- Students develop a model that accurately displays how the motion of particles of solids, liquids and gases would change when thermal energy is added or removed.
- To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including
  - particles, including their motion.
  - the system within which the particles are contained.
  - the average kinetic energy of particles in the system.
  - thermal energy of the system.
  - temperature of the system.
  - a pure substance in one of the states of matter (e.g., solid, liquid, or gas at the macro scale).
- In a given model, students describe the relationships between the temperature of the particles in a substance and the motion of the particles.
- In a given model, students describe the relationship between the motion of molecules in a system and the kinetic energy of the particles in the system.
- In a given model, students describe the relationship between the average kinetic energy of the particles and the temperature of the system.
- In a given model, students describe the relationship changes to particle motion, temperature, and the state of a pure substance when thermal energy is added or removed.

<u>Stimulus Materials</u>

Graphic organizers, diagrams, graphs, data tables, drawings

<u>Sample Stems</u>

The average human body temperature is 37°C.

1. Create a model that explains why a student's hands feel cool as hand sanitizer (which contains a high amount of alcohol) dries. The hand sanitizer is at room temperature of 20 degrees Celsius.

   In the model be sure to include the following:

   a. The motion of the particles in the bottle and while on the hand.
   b. Some hand sanitizer spilled on the table. Determine how the evaporation rate of the hand sanitizer on the hand compared to the hand sanitizer on the table.
   c. In each case (hand sanitizer on the hand and on the table) indicate the direction of heat transfer.

<table>
<tr><th colspan="2">Physical Sciences</th><th>6-8.PS1.B.1</th></tr>
<tr><td>Core Idea</td><td colspan="2">Matter and Its Interactions</td></tr>
<tr><td>Component</td><td colspan="2">Chemical reactions</td></tr>
<tr><td>MLS</td><td colspan="2">Develop and use a model to describe how the total number of atoms remains the same during a chemical reaction and thus mass is conserved.</td></tr>
<tr><td colspan="2" rowspan="2"><u>Expectation Unwrapped</u>

[Clarification statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.]

<u>SCIENCE AND ENGINEERING PRACTICES</u>
Developing and Using Models
● Develop a model to predict and/or describe phenomena.

<u>DISCIPLINARY CORE IDEAS</u>
Chemical Reactions
● Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
● The total number of each type of atom is conserved, and thus, the mass does not change.

<u>CROSSCUTTING CONCEPTS</u>
Energy and Matter
● Matter is conserved because atoms are conserved in physical and chemical processes.</td><td><u>DOK Ceiling</u>
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<tr><td><u>Item Format</u>
Selected Response
Constructed Response
Technology Enhanced</td></tr>
<tr><td colspan="2"><u>Content Limits/Assessment Boundaries</u>

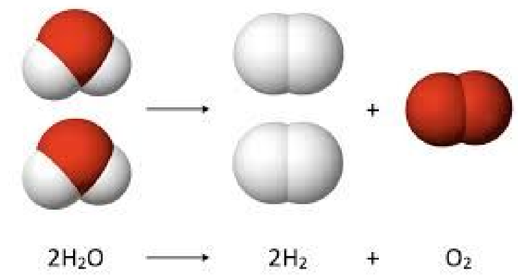
● Tasks should avoid the use of atomic masses, balancing equations, or intermolecular forces.</td><td><u>Sample Stems</u></td></tr>
</table>

Possible Evidence

- Students develop a model to identify the relevant components for a given chemical reaction, including the types and number of molecules that make up the reactants and products.
- Given a model, students describe the relationships between the components, including
  - that each molecule in each of the reactants is made up of the same type(s) and number of atoms.
  - when a chemical reaction occurs, the atoms that make up the molecules of reactants rearrange and form new molecules (i.e., products).
  - that the number and types of atoms that make up the products are equal to the number and types of atoms that make up the reactants. (Law of Conservation of Matter)
  - that each type of atom has a specific mass, which is the same for all atoms of that type.
- Given a model, students describe that the atoms that make up the reactants rearrange and come together in different arrangements to form the products of a reaction.
- Given a model, students use the model to provide an explanation that mass is conserved during chemical reactions because the number and types of atoms that are in the reactants equal the number and types of atoms that are in the products and all atoms of the same type have the same mass regardless of the molecule in which they are found.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings



A student looked at the diagram and made the following statement:
"The 2 grams of water form 2 grams of hydrogen and 1 gram of oxygen. "

1. Identify whether this statement is correct or incorrect.
2. What evidence is there that matter is conserved in this system?
3. Describe how you can set up an investigation to test the idea that matter is conserved.

Physical Sciences		6-8.PS1.B.2
Core Idea	**Matter and Its Interactions**	
Component	**Chemical reactions**	
MLS	Construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.	

<table>
<tr><td rowspan="2">

Expectation Unwrapped

[Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.]

SCIENCE AND ENGINEERING PRACTICES
Constructing Explanations and Designing Solutions
- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.

DISCIPLINARY CORE IDEAS
Chemical Reactions
- Some chemical reactions release energy, others store energy.

Developing Possible Solutions
- A solution needs to be tested and then modified on the basis of the test results in order to improve it.

Optimizing the Design Solution
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design.
- The process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately, to an optimal solution.

CROSSCUTTING CONCEPTS
Energy and Matter
- The transfer of energy can be tracked as energy flows through a designed or natural system.

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DOK Ceiling
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<tr><td>

Item Format
Selected Response
Constructed Response
Technology Enhanced

</td></tr>
</table>

Content Limits/Assessment Boundaries

- Tasks should limit test criteria to the amount, time, and temperature of a given substance when testing a device.
- Tasks should avoid the law of thermodynamics.

Possible Evidence

- Students construct and test a device that requires either heating or cooling.
- Students identify the components within a device that release or absorb thermal energy and where that energy transfer occurs.
- Students describe the principles of conduction and convection.
- Students identify types of materials that act as insulators or conductors.
- Students describe and/or identify the constraints (i.e., amount of time during which the device must function, safety, amount and cost of materials) of the device.
- Students analyze the data produced when testing a device designed to release or absorb heat.
- Students modify a device, based on data from testing, using new materials or changing the amount of chemicals to increase the efficiency of the device.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Sample Stems

Students were challenged to construct a passive solar heating greenhouse which retains most of its heat during the night. Using fire or a plug in device to heat the greenhouse during the night time.

1. Identify the forms of energy that are involved in this system.

2. What energy is entering, staying, and leaving the system?

3. List three design options students can test in their greenhouse models.

<table>
<tr><th colspan="2">Physical Sciences</th><th>6-8.PS2.A.1</th></tr>
<tr><td>Core Idea</td><td colspan="2">Motion and Stability: Forces and Interactions</td></tr>
<tr><td>Component</td><td colspan="2">Forces and Motion</td></tr>
<tr><td>MLS</td><td colspan="2">Apply physics principles to design a solution that minimizes the force of an object during a collision and develop an evaluation of the solution.</td></tr>
<tr><td colspan="2" rowspan="2"><u>Expectation Unwrapped</u>

[Clarification Statement: Newton's third law of motion states that for every action, there is an equal but opposite action. Using this principle, design a solution that would minimize the force of an object during a collision and evaluate the proposed solution. (Examples include collisions between cars, between a car and a stationary object, etc.)]

<u>SCIENCE AND ENGINEERING PRACTICES</u>
Constructing Explanations and Designing Solutions
● Apply scientific ideas or principles to design an object, tool, process, or system.

<u>DISCIPLINARY CORE IDEAS</u>
Forces and Motion
● For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first but in an opposite direction. (Newton's third law)

<u>CROSSCUTTING CONCEPTS</u>
Systems and System Models
● Models can be used to represent systems and their interactions, such as inputs, processes, and outputs, and energy and matter flows within systems.</td><td><u>DOK Ceiling</u>
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<tr><td><u>Item Format</u>
Selected Response
Constructed Response
Technology Enhanced</td></tr>
<tr><td colspan="2"><u>Content Limits/Assessment Boundaries</u>

● Tasks should be limited to vertical or horizontal interactions in one direction.</td><td><u>Sample Stems</u>

Students observe a video of two astronauts on the International Space Station (ISS) demonstrating a scientific principle. The ISS is in a microgravity environment. That means that astronauts experience weightlessness in the ISS. The students observe one astronaut push on the second astronaut's back while</td></tr>
</table>

Possible Evidence

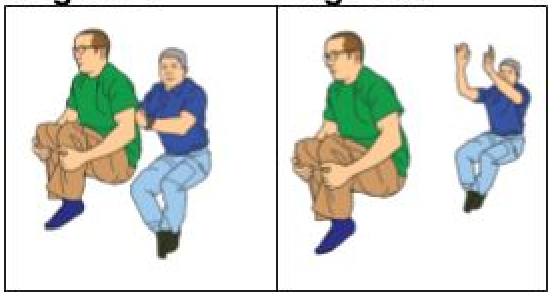
- Given a problem involving a collision between objects, students design a solution that would minimize the force of an object.
- Students describe and/or identify the criteria that are appropriate to solve the given problem.
- Students describe and/or identify the constraints (cost, mass and speed of objects, time, materials).
- Students describe, identify, and/or explain the physics principles involved in determining the solution to the given problem.
- Students evaluate a possible solution to the given problem.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

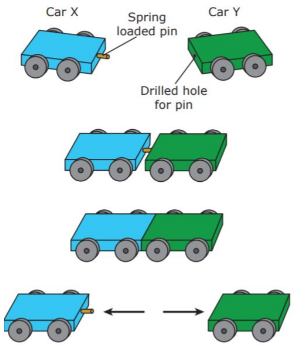
both are floating near each other. As a result of the push, both astronauts move away from each other in opposite directions. Figure 1 shows the astronauts inside the ISS floating near each other. Figure 2 shows the astronauts moving away from each other

Figure 1 **Figure 2**



To better understand the ISS demonstration, the students constructed two cars from wood blocks. A hole was drilled into a side of each block. A spring attached to a pin was inserted into one block and used to exert an initial force after the cars were released. The setup is shown in Figure 3.

Figure 3



The students changed some variables and repeated the investigation several times. Table 1 shows the average data collected.

Table 1: Observed Data

Trial	Mass (kg)		Distance (m)	
	Car X	Car Y	Car X	Car Y
1	0.15	0.15	1.50	1.50
2	0.15	0.30	1.80	0.75
3	0.30	0.15	0.75	1.80
4	0.30	0.30	0.75	0.75

1. Identify the key parts of the system.
2. At this point, which trial demonstrates the best solution to minimize the impact of the collision?
3. What would happen in this system if you increased the surface friction?
4. What would happen in this system if you increased the stiffness of the spring.
5. What would happen in this system if you added oil on the wheels?

<table>
<tr><th colspan="2">Physical Sciences</th><th>6-8.PS2.A.2</th></tr>
<tr><td>Core Idea</td><td colspan="2">Motion and Stability: Forces and Interactions</td></tr>
<tr><td>Component</td><td colspan="2">Forces and Motion</td></tr>
<tr><td>MLS</td><td colspan="2">Plan and conduct an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.</td></tr>
<tr><td colspan="2" rowspan="2"><u>Expectation Unwrapped</u>

[Clarification Statement: Emphasis is on balanced (Newton’s first law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton’s second law), frame of reference, and specification of units.]

<u>SCIENCE AND ENGINEERING PRACTICES</u>
Planning and Carrying Out Investigations
● Plan an investigation and identify the independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

<u>DISCIPLINARY CORE IDEAS</u>
Forces and Motion
● The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
● All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

<u>CROSSCUTTING CONCEPTS</u>
Stability and Change
● Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.</td><td><u>DOK Ceiling</u>
3</td></tr>
<tr><td><u>Item Format</u>
Selected Response
Constructed Response
Technology Enhanced</td></tr>
</table>

<u>Content Limits/Assessment Boundaries</u>

- Tasks should be limited to forces and changes in motion in one-dimension in an inertial reference frame.
- Tasks should only change one variable at a time.
- Tasks should not include trigonometry.

<u>Possible Evidence</u>

- Students identify the phenomenon under investigation, which includes the change in motion of an object.
- Students identify the purpose of the investigation, which includes providing evidence that the change in an object’s motion is due to the balanced or unbalanced forces acting on the object and the mass of the object.
- Students develop a plan and conduct an investigation. In the plan, students describe and/or identify that data on the motion of the object, on the total forces acting on the object, and the data on the mass of the object will be collected.
- Students describe which data are needed to provide evidence that an object subjected to balanced forces does not change its motion and an object subjected to unbalanced forces changes its motion over time. Also that the change in the motion of an object subjected to unbalanced forces depends on the mass of the object.
- In the plan of an investigation, students describe how the following factors will be measured:
    - The motion of the object, including a specified reference frame and appropriate units for distance and time.
    - The mass of the object, including appropriate units
    - The forces acting on the object, including balanced and unbalanced forces
- Students describe how variables will be identified and controlled when planning and conducting an investigation.

<u>Stimulus Materials</u>

Graphic organizers, diagrams, graphs, data tables, drawings

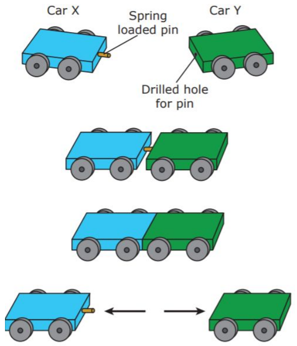
<u>Sample Stems</u>

Students observe a video of two astronauts on the International Space Station (ISS) demonstrating a scientific principle. The ISS is in a microgravity environment. That means that astronauts experience weightlessness in the ISS. The students observe one astronaut push on the second astronaut’s back while both are floating near each other. As a result of the push, both astronauts move away from each other in opposite directions. Figure 1 shows the astronauts inside the ISS floating near each other. Figure 2 shows the astronauts moving away from each other

Figure 1 Figure 2

To better understand the ISS demonstration, the students constructed two cars from wood blocks. A hole was drilled into a side of each block. A spring attached to a pin was inserted into one block and used to exert an initial force after the cars were released. The setup is shown in Figure 3.

Figure 3



The students changed some variables and repeated the investigation several times. Table 1 shows the average data collected.

Table 1: Observed Data

Trial	Mass (kg)		Distance (m)	
	Car X	Car Y	Car X	Car Y
1	0.15	0.15	1.50	1.50
2	0.15	0.30	1.80	0.75
3	0.30	0.15	0.75	1.80
4	0.30	0.30	0.75	0.75

1. a. Describe two variables that will have the greatest effect on the distance traveled by each astronaut in the demonstration described by Figure 1 and Figure 2.

Physical Sciences		6-8.PS2.B.1
Core Idea	**Motion and Stability: Forces and Interactions**	
Component	**Types of Interaction**	
MLS	Analyze diagrams and collect data to determine the factors that affect the strength of electric and magnetic forces.	

Expectation Unwrapped

[Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet or the effect of increasing the number or strength of magnets on the speed of an electric motor.]

SCIENCE AND ENGINEERING PRACTICES

Analyzing and Interpreting Data

- Analyze and interpret data to provide evidence for phenomena.

DISCIPLINARY CORE IDEAS

Types of Interactions

- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.

CROSSCUTTING CONCEPTS

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems.

DOK Ceiling

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Item Format

Selected Response
Constructed Response
Technology Enhanced

Content Limits/Assessment Boundaries

- Tasks that require quantitative answers are limited to proportional reasoning and algebraic thinking.

Sample Stems

Magnet and Paperclip Investigation

Magnet	number of paper clips	distance from the clips (cm)
X	4	1.0
Y	9	0.5

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Possible Evidence

- Given a diagram and/or data table, students predict the effect on the strength of the electric and/or magnetic force.
- Given changing distances, students determine the effect on magnetic forces.
- Students analyze a diagram illustrating different factors related to the effect of the electric current (e.g., number of turns of wire in a coil) to determine the effect on the magnetic force.
- Students organize data into a workable format for analysis.

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The table above organizes data from a short investigation a student did.

1. a. Does the data support a variable as the cause for the number of paperclips a magnet can pick up?
b. Explain your answer to Part A.

2. List two pieces of information which would help the student be able to make a claim about the data.

3. How can you test whether distance or magnet strength caused changes in the number of paper clips to happen?

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Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

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<table>
<tr><th colspan="2">Physical Sciences</th><th>6-8.PS2.B.2</th></tr>
<tr><td>Core Idea</td><td colspan="2">Motion and Stability: Forces and Interactions</td></tr>
<tr><td>Component</td><td colspan="2">Types of Interaction</td></tr>
<tr><td>MLS</td><td colspan="2">Create and analyze a graph to use as evidence to support the claim that gravitational interactions depend on the mass of interacting objects.</td></tr>
<tr><td colspan="2" rowspan="2"><u>Expectation Unwrapped</u>

[Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.]

<u>SCIENCE AND ENGINEERING PRACTICES</u>
Analyzing and Interpreting Data
● Analyze and interpret data to provide evidence for phenomena.

<u>DISCIPLINARY CORE IDEAS</u>
Types of Interactions
● Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small, except when one or both of the objects have a large mass (e.g., Earth, the sun).

<u>CROSSCUTTING CONCEPTS</u>
Systems and System Models
● Models can be used to represent systems and their interactions, such as inputs, processes and outputs, and energy and matter flows within systems.</td><td><u>DOK Ceiling</u>
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<tr><td><u>Item Format</u>
Selected Response
Constructed Response
Technology Enhanced</td></tr>
<tr><td colspan="2"><u>Content Limits/Assessment Boundaries</u>

● Tasks should not include Newton’s or Kepler’s laws.
● Tasks should provide students with the data sets needed to produce a graph.
● Tasks should provide the assumption of no air resistance.</td><td><u>Sample Stems</u>

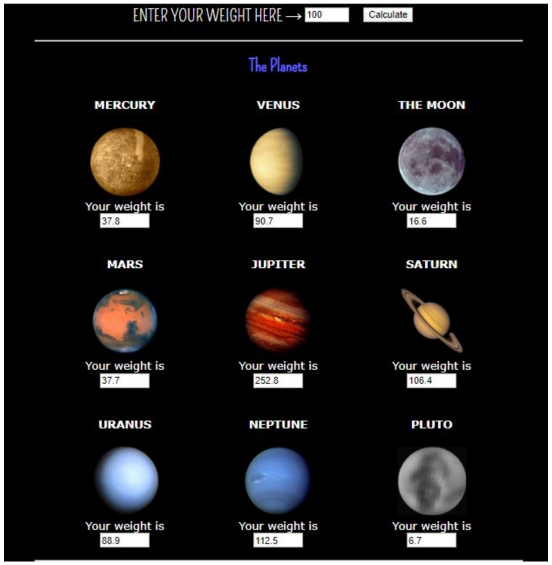
Using the Exploratorium: Your Weight on Other Planets calculator, a student found their weight on the planets in our solar system.</td></tr>
</table>

Possible Evidence

- Given data, students create a graph to support the claim that the masses of interacting objects affect the gravitational force between them. (i.e., the Earth/Sun/moon system and orbital periods of objects within the solar system).
- Students analyze data, graphs, and/or charts to use as evidence that gravitational forces depend on the masses of the objects.
- Students defend the data generated to support a claim about the gravitational interactions between objects.
- Students make a prediction of what happens to the gravitational force if the mass of the object changes.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings



THe student did a bit more research to find the mass and diameter of the planets.

	MERCURY	VENUS	EARTH	MOON	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Mass (10^{24}kg)	0.330	4.87	5.97	0.073	0.642	1898	568	86.8	102	0.0146
Diameter (km)	4879	12,104	12,756	3475	6792	142,984	120,536	51,118	49,528	2370

1. Identify the parts of the solar system or variables that are being compared.
2. Create a graph of weight versus planet mass.
3. Create a graph of the student's weight versus planet diameter.
4. Does the weight of a person depend on the mass or the diameter of the planet that he or she is on? Use evidence from the graphs to support your answer.

Physical Sciences	6-8.PS2.B.3
Core Idea	**Motion and Stability: Forces and Interactions**
Component	**Types of Interaction**
MLS	Conduct an investigation and evaluate the experimental design to provide evidence that electric and magnetic fields exist between objects exerting forces on each other even though the objects are not in contact.

Expectation Unwrapped

[Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.]

SCIENCE AND ENGINEERING PRACTICES

Planning and Carrying Out Investigations

- Conduct an investigation and evaluate the experimental design (identify variables and controls, what tools are needed, how measurements are taken and recorded, how many trials are needed) to provide evidence that electric and magnetic fields exist between objects.

DISCIPLINARY CORE IDEAS

Types of Interactions

- Forces that act at a distance (e.g., electric, magnetic) can be explained by fields that extend through space and can be mapped by their effect on a test object (e.g., a charged object, ball).

CROSSCUTTING CONCEPTS

Cause and Effect

- May be used to predict phenomena in natural or designed systems (i.e., electric and magnetic fields).

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Item Format

Selected Response
Constructed Response
Technology Enhanced

Content Limits/Assessment Boundaries

- Tasks should be limited to electric and magnetic fields.
- Tasks should be limited to qualitative evidence for the existence of electric and magnetic fields.

Sample Stems

Magnet and Paperclip Investigation

Magnet	number of paper clips	distance from the clips (cm)
X	4	1.0
Y	9	0.5

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<u>Possible Evidence</u>

- Students describe the rationale for why the given investigation plan includes
    - changing the distance between objects.
    - changing the charge or magnetic orientation of objects.
    - changing the magnitude of the charge on an object or the strength of the magnetic field.
    - a means to indicate or measure the presence of electric or magnetic forces.
- Students conduct an investigation to demonstrate that fields exist between objects exerting forces on each other even when not in contact with each other (electric/magnetic).
- Students evaluate the experimental design of an investigation designed to provide evidence that electric and magnetic fields exist and that objects exert forces on each other do not have to be in contact with each other.
- Students explain that electric forces can be repulsive or attractive.
- Students explain that electric and magnetic forces are dependent on the magnitude of the charges and distance between objects.
- Students make and record observations and data regarding motion of objects, such as a push or pull exerted on the hand of an observer holding an object.
- Students distinguish between electric and magnetic forces.

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A student did a short investigation regarding the power of magnets. The data from the investigation is listed above table.

1. Using the data table, evaluate the investigation.

2. Identify the following variables found in this investigation:
    a. Independent variable:
    b. Dependent variable:
    c. Constants:
    d. Possible Hypothesis:

3. Describe how you can test whether distance or type of magnet caused the difference in the number of paperclips picked up.

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<u>Stimulus Materials</u>

Graphic organizers, diagrams, graphs, data tables, drawings

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Physical Sciences		6-8.PS3.A.1
Core Idea	**Energy**	
Component	**Definitions of Energy**	
MLS	Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and the speed of an object.	

Expectation Unwrapped

[Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

SCIENCE AND ENGINEERING PRACTICES

Analyzing and Interpreting Data

- Construct and interpret graphical displays of data to describe relationships between kinetic energy and the mass of an object and the speed of the object.

DISCIPLINARY CORE IDEAS

Definitions of Energy

- Motion energy is called kinetic energy. Kinetic energy is proportional to the mass of the moving object and grows with the speed of the object.

CROSSCUTTING CONCEPTS

Scale, Proportion, and Quantity

- Proportional relationships (speed as a ratio of distance traveled to time taken) between different types of quantities provide information about the magnitude, properties, and processes.

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Item Format

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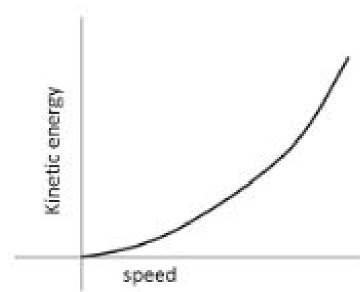
Constructed Response
Technology Enhanced

Content Limits/Assessment Boundaries

- Tasks should not assess the formula for kinetic energy.
- Tasks should provide all needed data sets.

Sample Stems

Figure 1



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<u>Possible Evidence</u>

- Construct graphical displays to organize given data such as the mass, speed, and kinetic energy in a way that would make interpretation possible.
- Given a graphical display, identify that kinetic energy increases if either the mass or the speed of the object increases or if both increase.
- Given a graphical display, identify that kinetic energy decreases if either the mass or the speed of the object decreases or if both decrease.
- Make a prediction of the proportional relationships of kinetic energy.

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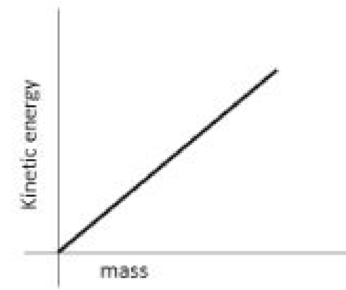
Figure 2



The two graphs compare different variables against kinetic energy. Figure 1 compares the speed of the object and the kinetic energy. Figure 2 compares the mass of the object and the kinetic energy.

1. Describe how the relationship between the mass and kinetic energy compared to the relationship between the speed and kinetic energy.

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<u>Stimulus Materials</u>

Graphic organizers, diagrams, graphs, data tables, drawings

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Physical Sciences		6-8.PS3.A.2
Core Idea	**Energy**	
Component	**Definitions of Energy**	
MLS	Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.	

Expectation Unwrapped	DOK Ceiling / Item Format
[Clarification Statement: Emphasis is on relative amounts of potential energy. Examples of objects within systems interacting at varying distances could include Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] **SCIENCE AND ENGINEERING PRACTICES** **Developing and Using Models** ● Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. **DISCIPLINARY CORE IDEAS** **Definitions of Energy** ● A system of objects may also contain stored (potential) energy, depending on their relative positions. **Relationships Between Energy and Forces** ● When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. **CROSSCUTTING CONCEPTS** **Systems and System Models** ● Models can be used to represent systems and their interactions, and energy and matter flows within systems.	**DOK Ceiling** 3 **Item Format** Selected Response Constructed Response Technology Enhanced

Content Limits/Assessment Boundaries	Sample Stems
● Tasks should be limited to the electric, magnetic, and gravitational interactions between two objects.	There are different roller coasters across the country. The top three coasters with the largest hill drops and subsequent speeds are listed below.

Possible Evidence

- Students develop a model involving two objects interacting at a distance, identify the forces (electric, magnetic, gravitational) through which the two objects interact, and identify the distance between the objects.
- Within the model, students identify and describe the force that each object exerts on the other.
- Within the model, with the relative position of two objects changing, students describe that the potential energy of the system changes.
- Students use or identify a model that illustrates the relationship between the forces applied and the resulting transfer of energy.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Table 1

Rollercoaster	Hill drop (m)	Speed (kph)
Kingda Ka	127	206
Top Thrill	120	190
Red Force	112	180

1. Using the data provided, write a claim for how the height of the drop affects how fast the roller coaster travels.

Physical Sciences		6-8.PS3.A.3
Core Idea	**Energy**	
Component	**Definitions of Energy**	
MLS	Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.	

Expectation Unwrapped	**DOK Ceiling**
[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.]	3

Item Format
Selected Response
Constructed Response
Technology Enhanced

SCIENCE AND ENGINEERING PRACTICES

Constructing Explanations and Designing Solutions
- Apply scientific ideas or principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

DISCIPLINARY CORE IDEAS

Definitions of Energy
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

Conservation of Energy and Energy Transfer
- Energy is spontaneously transferred out of hotter regions or objects into colder ones.

Defining and Delimiting an Engineering Problem
- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.

Developing Possible Solutions
- A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.

CROSSCUTTING CONCEPTS

Energy and Matter
- The transfer of energy can be tracked as energy flows through a designed or natural system.

Content Limits/Assessment Boundaries

- Tasks should not require students to calculate the total amount of thermal energy transferred.

Possible Evidence

- Given a problem to solve that requires either minimizing or maximizing thermal energy transfer, students design and build a solution to the problem.
- Students test the designed device.
- Students identify that thermal energy is transferred from hotter objects to colder objects.
- Students describe different types of materials used in the design solution and their properties (e.g., thickness, heat conductivity, reflectivity) and how these materials will be used to minimize or maximize thermal energy transfer.
- Students specify how the device will solve the problem.
- Students define thermal energy and how it is transferred.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings.

Sample Stems

Dairy farmers try to conserve energy while keeping their milk products safe. They would like to design containers using thermal insulation to maintain the correct temperature and prevent the growth of bacteria. Thermal conductivity measures the ability to allow heat flow.

Material costs and availability of resources used are also factors that the farmers considered in identifying the best design. Table 1 shows test data for some common thermal insulators. Thermal insulators with lower thermal conductivity values allow less heat flow.

Table 1: Thermal Insulation Characteristics

Type of Insulation	Density (kg/m^3)	Thermal Conductivity (per meter thick)	Notes
Foam	30	0.026	expensive
Cork	150	0.046	limited resource
Fiberglass	14	0.044	absorbs water

1. When milk is being processed, it must be kept warm enough to kill harmful bacteria. When it is taken in trucks to stores, it must be kept cool enough to stop bacteria from growing.
    a. Where and when in the system is the energy needed

	to stay in the milk? leave the milk? b. For these criteria, identify a material you would you choose to test. c. Explain your reasoning to Part B. 2. Fiberglass is made of particles of glass surrounded by air, while foam contains bubbles of gas that cannot escape. Complete the sentences below. The foam has a _________ density because of the gas. If there were no bubbles in the material, there would be a _______ density. The thermal conductivity would be ______.

Physical Sciences		6-8.PS3.A.4
Core Idea	**Energy**	
Component	**Definitions of Energy**	
MLS	Plan and conduct an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the temperature of the sample.	

Expectation Unwrapped	**DOK Ceiling**
	3
[Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] **SCIENCE AND ENGINEERING PRACTICES** **Planning and Carrying Out Investigations** ● Plan an investigation, and in the design, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **DISCIPLINARY CORE IDEAS** **Definitions of Energy** ● Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **Conservation of Energy and Energy Transfer** ● The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter and the size of the sample. **CROSSCUTTING CONCEPTS** **Scale, Proportion, and Quantity** ● It is critical to recognize what is relevant at different measures of size, time, and energy and how it changes in scale and proportion affects the transfer of energy.	**Item Format** Selected Response Constructed Response Technology Enhanced

Content Limits/Assessment Boundaries

- Tasks should not require students to calculate the total amount of thermal energy transferred.
- Tasks should limit calculations to proportionate thinking.

Possible Evidence

- Students identify the phenomenon under investigation involving thermal energy transfer.
- Students describe the purpose of the investigation, including determining the relationships between the following factors: the transfer of thermal energy, the type of matter, the mass of the matter involved in thermal energy transfer, and the change in the temperature.
- Students design an investigation that describes the data to be collected and the evidence to be derived from the data, including
  - initial and final temperatures of the materials used in the investigation.
  - types of matter used in the investigation.
  - mass of matter used in the investigation.
- Students provide evidence of proportional relationships between changes in temperature of materials and the mass of those materials.
- Students relate the changes in temperature in the sample to the types of matter and to the change in the average kinetic energy of the particles.
- Students describe how the mass of the materials is to be measured and in what units.
- Students describe how and when the temperatures of the materials are to be measured and in what units.
- Students describe the details of the experimental conditions that will allow the appropriate data to be collected to address the purpose of the investigation (e.g., time between temperature measurements, amounts of sample used, types of materials used), including appropriate independent and dependent variables and controls.

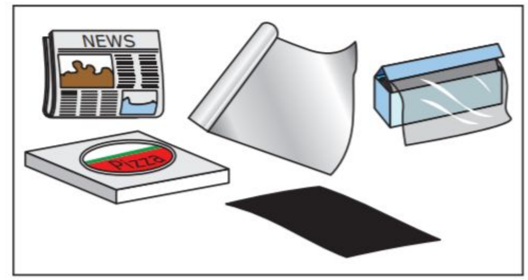
Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Sample Stems

A group of students want to create a device that will cook food using energy from the Sun. Their goal is to design a solar cooker that will maximize the rate of cooking. Figure 1 shows the materials available to the students which include newspaper, plastic wrap, aluminum foil, black construction paper, and a pizza box.

Figure 1: Available Materials



1. What measurements would they make to determine the dependent variable?
2. When testing how energy is transferred within the solar cooker, the students find that the temperature of the air in the cooker increases more quickly than the temperature of the food in the cooker. What factors of the matter being measured cause this phenomenon?

Physical Sciences		6-8.PS3.B.1
Core Idea	**Energy**	
Component	**Conservation of Energy and Energy Transfer**	
MLS	Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.	

Expectation Unwrapped

[Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of an object.]

SCIENCE AND ENGINEERING PRACTICES

Engaging in Argument from Evidence

- Construct, use, and present written or oral arguments supported by evidence and scientific reasoning to support or refute an explanation for when the kinetic energy of an object changes, energy is transferred to or from the object.

DISCIPLINARY CORE IDEAS

Conservation of Energy and Energy Transfer

- When the kinetic energy of an object changes, the energy is transferred from one object to another.

CROSSCUTTING CONCEPTS

Energy and Matter

- Energy may take different forms (e.g.energy in fields, thermal energy, energy of motion).

DOK Ceiling

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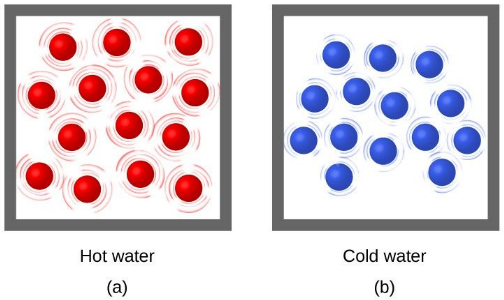
Item Format

Selected Response
Constructed Response
Technology Enhanced

Content Limits/Assessment Boundaries

- Tasks should not include calculations of energy.
- Tasks should provide students with all needed text, diagrams, and/or graphs to use as evidence.

Sample Stems



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Possible Evidence

- When given an explanation or model for a phenomenon, students explain the idea that when the kinetic energy of an object changes, energy is transferred to or from that object.
- Students identify and describe the given evidence that supports a claim that observable features (e.g., motion, temperature, sound) of the objects change after the interaction that changes the kinetic energy of the original object.
- Students describe a chain of reasoning that includes the changes in the observable features of the object (e.g., motion, temperature) and when the kinetic energy of the object changes.
- Students describe a chain of reasoning that includes when the kinetic energy of the object increases or decreases, the energy (e.g., kinetic, thermal, potential) of other objects or the surroundings within the system increases or decreases, and indicating that energy was transferred to or from the object.
- Students present written arguments to support or refute the given explanation or model for the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

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A student made the following claim:
“Temperature is the measure of the average kinetic energy of particles which make up a substance.”

1. Using the model provided, construct an argument how hot water cools.

For the following, we will assume both boxes are glass containers of the same water.

1. a. Initially, the glass contained hot water, however over time, left on the counter, the water cooled. What energy is being transferred in the described system?
b. Where is the energy described in part A being transferred to?

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Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

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Physical Sciences	6-8.PS4.A.1

Core Idea	**Waves and Their Applications in Technologies for Information Transfer**
Component	**Wave Properties**
MLS	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

<u>Expectation Unwrapped</u>

[Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.]

<u>SCIENCE AND ENGINEERING PRACTICES</u>

Using Mathematics and Computational Thinking

- Use mathematical representations to describe and/or support scientific conclusions and design solutions.

<u>DISCIPLINARY CORE IDEAS</u>

Wave Properties

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.

<u>CROSSCUTTING CONCEPTS</u>

Patterns

- Graphs, diagrams, and charts can be used to identify patterns in data.

<u>DOK Ceiling</u>

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<u>Item Format</u>

Selected Response
Constructed Response
Technology Enhanced

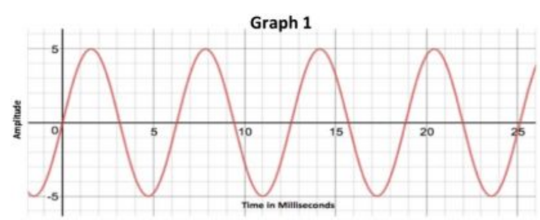
<u>Content Limits/Assessment Boundaries</u>

- Tasks are limited to standard, repeating waves.
- Tasks should not require students to calculate amplitude or frequency.

<u>Possible Evidence</u>

- Students identify the characteristics of a simple mathematical wave model of a phenomenon, including that
  - waves represent repeating quantities.
  - frequency is the number of times the pattern repeats in a given amount of time (e.g., beats per second).
  - amplitude is the maximum extent of the repeating quantity from equilibrium (e.g., height or depth of a water wave from average sea level).

<u>Sample Stems</u>



A student played a note and recorded it with the graph 1.

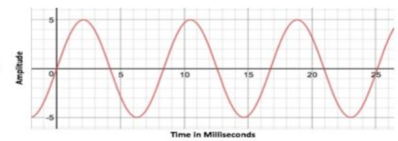
1. If the student wanted to increase the pitch of the note, which graph would be produced?

    - wavelength is as a certain distance in which the quantity repeats its value (e.g., the distance between the tops of a series of water waves).
- Students apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations (e.g., frequency corresponds to sound pitch, amplitude corresponds to sound volume).

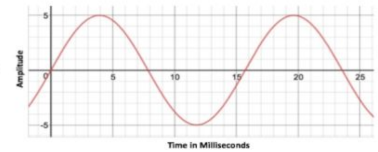
Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

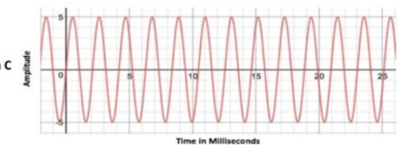
Graph A



Graph B



Graph C



2. What pattern in the graphed data did you use to determine the answer to Question 1?

Physical Sciences		6-8.PS4.A.2
Core Idea	**Waves and Their Applications in Technologies for Information Transfer**	
Component	**Wave Properties**	
MLS	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	

Expectation Unwrapped	**DOK Ceiling**
[Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] **SCIENCE AND ENGINEERING PRACTICES** **Developing and Using Models** ● Develop and use a model to describe phenomena. **DISCIPLINARY CORE IDEAS** **Wave Properties** ● A sound wave needs a medium through which it is transmitted. **Electromagnetic Radiation** ● When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. ● The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. ● However, because light can travel through space, it cannot be considered to only move through matter, like sound or water waves. **CROSSCUTTING CONCEPTS** **Structure and Function** ● Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.	3 **Item Format** Selected Response Constructed Response Technology Enhanced
Content Limits/Assessment Boundaries	**Sample Stems**
● Tasks should be limited to qualitative applications pertaining to light and mechanical waves.	

Possible Evidence

- Students develop a model and identify the relevant components.
  - Type of wave:
    - Matter waves (e.g., sound or water waves) and their amplitudes and frequencies
    - Light, including brightness (amplitude) and color (frequency)
  - Various materials through which the waves are reflected, absorbed, or transmitted
  - Relevant characteristics of the wave after it has interacted with a material (e.g., frequency, amplitude, and wavelength)
  - Position of the source of the wave
- Students identify and describe the relationships between components, including waves interact with materials and mediums by being reflected, absorbed, or transmitted.
- Students describe how light travels in straight lines, but the path of light is bent at the interface between materials when it travels from one material to another.
- Students describe how light does not require a material for propagation (e.g., space), but matter waves do require a material for propagation.
- Students use a model to explain reflection, absorption, and/or transmission properties of different materials for light and matter waves.
- Students use models to describe the differences between how light and matter waves interact with different materials.
- Students use models to describe why materials with certain properties are well suited for particular functions (e.g., lenses and mirrors, sound absorbers in concert halls, colored light filters, sound barriers next to highways).

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Table 1

Velocity of Sound in Various Media

Media	Density (kg per cubic meter)	Velocity (m/s)
Air	1.0	343.0
Pure Water	1,000.0	1,493.0
Sea Water	1,020.0	1,533.0
Glass	2,600.0	4,540.0
Iron	7,870.0	5,130.0
Lead	11,350.0	1,158.0

1. Using the data above, develop a model which explains why the speed of sound is faster in solids and liquids than gases.

2. Describe the organization of particles and how the spatial relationship matters for behavior and function.

<table>
<tr><th colspan="2">Engineering, Technology, and Application of Science</th><th>6-8.ETS1.A.1</th></tr>
<tr><td>Core Idea</td><td colspan="2">Engineering Design</td></tr>
<tr><td>Component</td><td colspan="2">Defining and Delimiting Engineering Problems</td></tr>
<tr><td>MLS</td><td colspan="2">Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.</td></tr>
<tr><td colspan="2" rowspan="2"><u>Expectation Unwrapped</u>

<u>SCIENCE AND ENGINEERING PRACTICES</u>
Asking Questions and Defining Problems
● Define a design problem that can be solved through the development of an object, a tool, a process or a system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

<u>DISCIPLINARY CORE IDEAS</u>
Defining and Delimiting Engineering Problems
● The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

<u>CROSSCUTTING CONCEPTS</u>
Influence of Science, Engineering, and Technology on Society and the Natural World
● All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment.
● The uses of technologies limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.</td><td><u>DOK Ceiling</u>
3</td></tr>
<tr><td><u>Item Format</u>
Selected Response
Constructed Response
Technology Enhanced</td></tr>
<tr><td colspan="2"><u>Content Limits/Assessment Boundaries</u>

● Tasks should not require students to develop a solution for a given design problem.</td><td><u>Sample Stems</u>

Each year, students in 7th grade science class are given the task of designing and producing a hand warmer. Out of the list below, organize the items into two groups, criteria and constraints.</td></tr>
</table>

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<u>Possible Evidence</u>

Given a problem to solve involving a collision of two objects students will

describe the criteria and constraints of the problem.
identify and describe the scientific principles that could constrain the possible solutions.

Given a problem to solve that requires either heating or cooling, students will

identify the criteria including features of the given problem that are to be solved by the device.
Identify how the problem involves either heating or cooling by chemical reaction.

Given a problem to solve, students identify constraints which could include amount and cost of materials, safety and amount of time.
Given a problem to solve, students will identify and describe the impacts on humans and the natural environment.

</td>
<td rowspan="2">

Maximum dimensions 5 cm x 8 cm
Use chemicals to produce heat
Have a cover made of material
Lasts at least 10 minutes
Where appropriate, use recyclable material
Be cost effective
Reach at least 40 degrees Celsius

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<tr>
<td>

<u>Stimulus Materials</u>

Graphic organizers, diagrams, graphs, data tables, drawings

</td>
</tr>
</table>

Engineering, Technology, and Application of Science — 6-8.ETS1.B.1

Core Idea	**Engineering Design**
Component	**Developing Possible Solutions**
MLS	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Expectation Unwrapped

SCIENCE AND ENGINEERING PRACTICES
Engaging in Argument from Evidence
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

DISCIPLINARY CORE IDEAS
Developing Possible Solutions
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.

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Item Format

Selected Response
Constructed Response
Technology Enhanced

Content Limits/Assessment Boundaries

- Tasks should provide students with all needed data, equations, and formulas.

Possible Evidence

- Given competing design solutions, students will
  - define the criteria and constraints of the problem.
  - identify the scientific knowledge in the problem and solutions.
  - identify and evaluate how each solution would solve the problem.
  - use a systematic method, such as a decision matrix, to identify the strengths and weaknesses of each solution.
  - use the evidence and reasoning to make a claim about the relative effectiveness of each proposed solution based on strengths and weaknesses.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Sample Stems

Evaluate the following choices for using a chemical as a heat source in the hand warmer. Any temperature higher than 44 degrees Celsius could burn the skin.

Materials	Magnesium Sulfate Anahydrate ($MgSO_4$)		Calcium Chloride($CaCl_2$)		Sodium Carbonate($NaCO_3$)	
Mass(g)	5.04 g	5 g	5.2 g	4.93 g	5.13 g	5.8 g
Initial Water Temp.(°C)	19.8°C	18.4°C	20.2°C	20.8°C	20.3°C	20.5°C
Final Water Temp.(°C)	23.6°C	20.6°C	27°C	27.6°C	25.1°C	28.8°C
Temperature Change(°C)	3.8°C	2.2°c.	6.8°C	6.8°C	4.8°C	8.8°C
Average Temp. Change Per Gram(°C/g)	.497(°C/g)	.497(°C/g)	1.34(°C/g)	1.34(°C/g)	1.24(°C/g)	1.24(°C/g)

Materials	Magnesium Chloride ($MgCl_2$)		Ammonium Nitrate (NH_4NO_3)		Strontium Chloride ($SrCl_2$)		Lithium Chloride(LiCl)	
Mass(g)	5.04g	5.24g	4.49g	5.01g	5.13g	5.14g	5.03g	5.19g
Initial Water Temp.(°C)	19.5°C	19.8°C	19.9°C	19.7°C	19.8°C	20°C	19.8°C	19.6°C
Final Water Temp.(°C)	20.4°C	20.9°C	13.9°C	14°C	18.8°C	18.4°C	35.9°C	36.3°C
Temperature Change(°C)	0.9°C	0.9°C	-6°C	-5.7°C	-1°C	-1.6°C	16.1°C	17.3°C
Average Temp. Change Per Gram(°C/g)	0.17 (°C/g)	0.17(°C/g)	-1.176(°C/g)	-1.176(°C/g)	-0.25 (°C/g)	-0.25(°C/g)	3.268(°C/g)	3.268(°C/g)

1. Identify which chemical you would choose.
2. Describe evidence for your answer to part A.

Engineering, Technology, and Application of Science		6-8.ETS1.B.2
Core Idea	**Engineering Design**	
Component	**Developing Possible Solutions**	
MLS	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	

Expectation Unwrapped	**DOK Ceiling**
SCIENCE AND ENGINEERING PRACTICES **Analyzing and Interpreting Data** ● Analyze and interpret data to determine similarities and differences in findings. **DISCIPLINARY CORE IDEAS** **Developing Possible Solutions** ● There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. ● Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **Optimizing the Design Solution** ● Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.	3 **Item Format** Selected Response Constructed Response Technology Enhanced
Content Limits/Assessment Boundaries	**Sample Stems**
● Tasks should avoid how to use absolute deviation.	Dairy farmers try to conserve energy while keeping their milk products safe. They would like to design containers using thermal insulation to maintain the correct temperature and prevent the growth of bacteria. Thermal conductivity measures the ability to allow heat flow.

Possible Evidence

- Students organize data effectively.
- Students use data including mean, mode, median, and range to analyze the relationships within the data.
- Students identify sources of error in investigations.
- Given data from tests intended to determine the effectiveness of three or more alternative solutions to a problem, students will organize data.
- Students will use appropriate analysis techniques (mean, mode, median, range) to analyze data and identify relationships within the data sets, including relationships between the design solutions, criteria, and constraints.
- Given several design solutions, students identify evidence of similarities and differences.
- Given data, students make a claim for which characteristics of each design best meet the given criteria and constraints.
- Students use the analyzed data to identify the best features of each proposed design that can be compiled into a new (improved) redesigned solution.

Stimulus Materials

Graphic organizers, diagrams, graphs, data tables, drawings

Material costs and availability of resources used are also factors that the farmers considered in identifying the best design. Table 1 shows test data for some common thermal insulators. Thermal insulators with lower thermal conductivity values allow less heat flow.

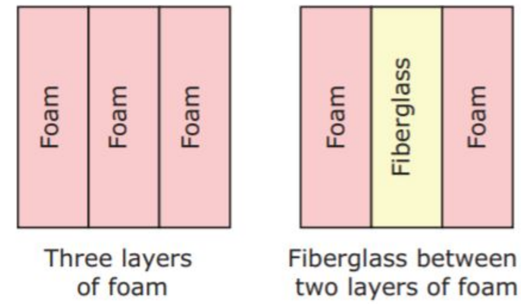
Table 1: Thermal Insulation Characteristics

Type of Insulation	Density (kg/m^3)	Thermal Conductivity (per meter thick)	Notes
Foam	30	0.026	expensive
Cork	150	0.046	limited resource
Fiberglass	14	0.044	abosrobs water

Dairy farmers have chosen to test two different insulating box designs. One will be used to take milk to stores. This box must not absorb water when it rains and should be as light as possible. The other box will be used to keep milk hot while it is processed inside a building where weight and water are not a problem.

Each box will be made from layers of foam or a combination of foam and fiberglass, as shown below.

Figure 1: Combination of Foam & Fiberglass



1. Write each answer in the correct boxes to match each characteristic to the correct type of layering.

A. Best insulator

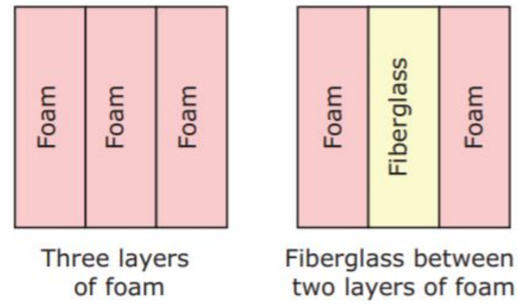
B. Lightest

C. Best for inside building

Three layers of foam	**Fiberglass between two layers of foam**

Engineering, Technology, and Application of Science		6-8.ETS1.B.3
Core Idea	**Engineering Design**	
Component	**Developing Possible Solutions**	
MLS	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	

Expectation Unwrapped	**DOK Ceiling**
	3
SCIENCE AND ENGINEERING PRACTICES **Developing and Using Models** ● Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. **DISCIPLINARY CORE IDEAS** **Developing Possible Solutions** ● A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. ● Models of all kinds are important for testing solutions. **Optimizing the Design Solution** ● The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	**Item Format** Selected Response Constructed Response Technology Enhanced
Content Limits/Assessment Boundaries ● Tasks should provide students will all needed data, equations, and formulas. **Possible Evidence** ● Students identify models that generate data for repeated testing. ● Students explain how the data generated by the model, along with identified criteria and constraints that the proposed solution must meet, can be used to improve the design solution. **Stimulus Materials** Graphic organizers, diagrams, graphs, data tables, drawings	**Sample Stems** Dairy farmers have chosen to test two different insulating box designs. One will be used to take milk to stores. This box must not absorb water when it rains and should be as light as possible. The other box will be used to keep milk hot while it is processed inside a building where weight and water are not a problem. Each box will be made from layers of foam or a combination of foam and fiberglass, as shown below.

	 1. Describe the best way to investigate which box is the best at insulating.